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(54) **MID-TURBINE FRAME ASSEMBLY**

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| ***F01D 25/12*** | (2006.01) |
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USPC ........ 415/182.1, 213.1, 214.1; 411/167, 169, 411/170, 172–175

See application file for complete search history.

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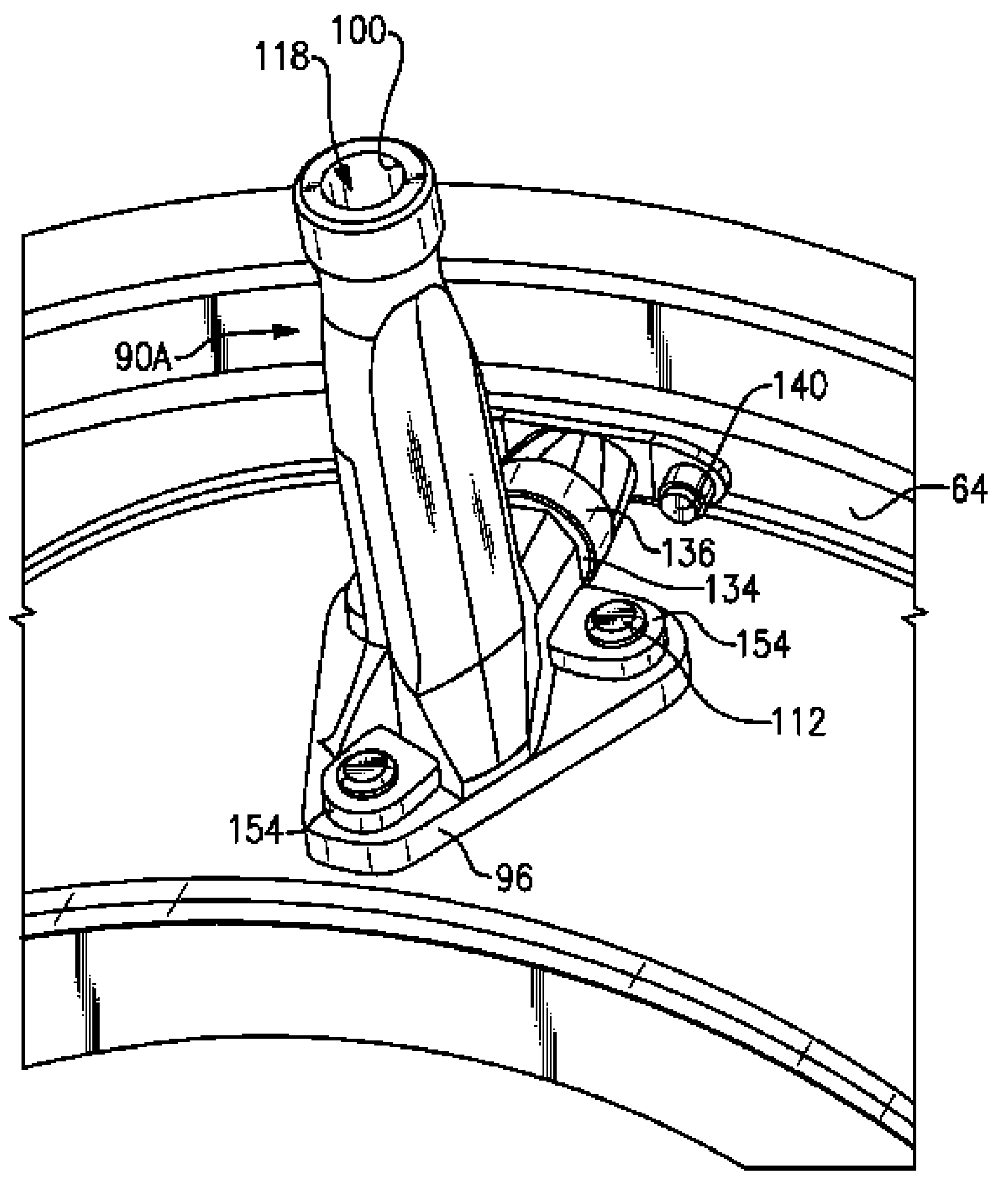
(57) **ABSTRACT**

A fastener assembly includes a first component that includes a bushing opening. A second component includes a fastener opening. A threaded bushing is at least partially located within the bushing opening. A fastener extends through the fastener opening and engages the bushing.

**9 Claims, 5 Drawing Sheets**



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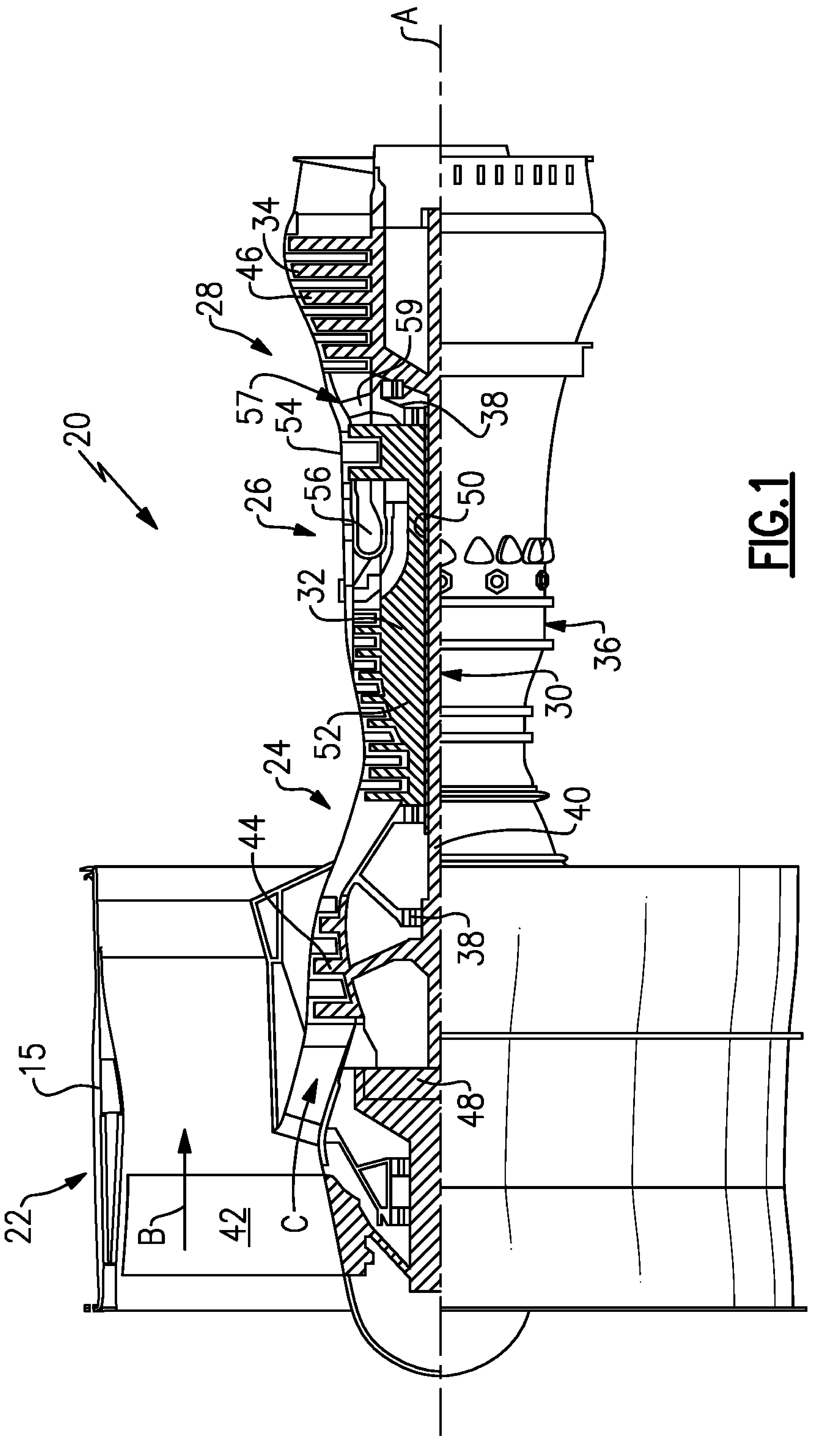

FIG.1

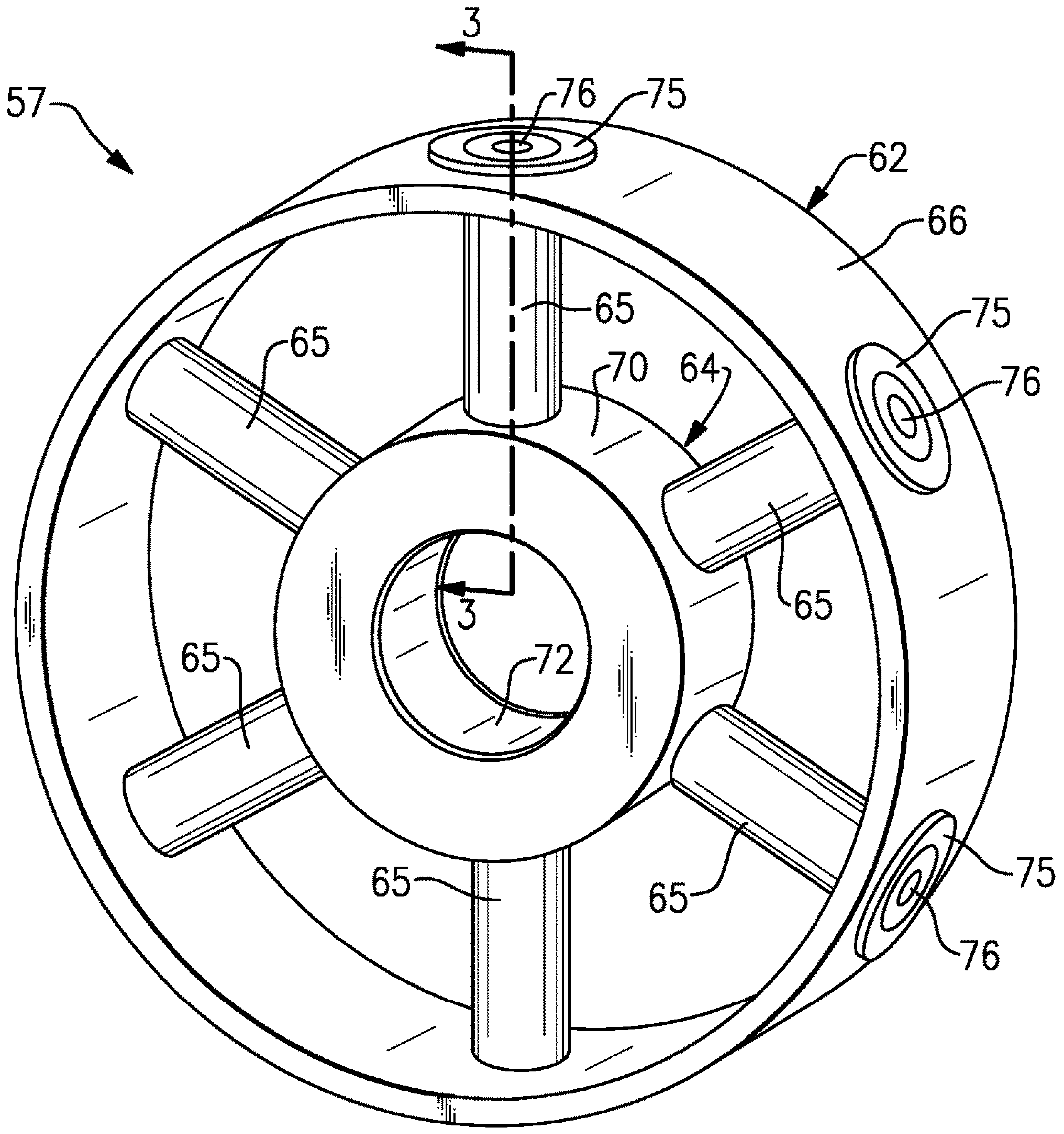

FIG.2

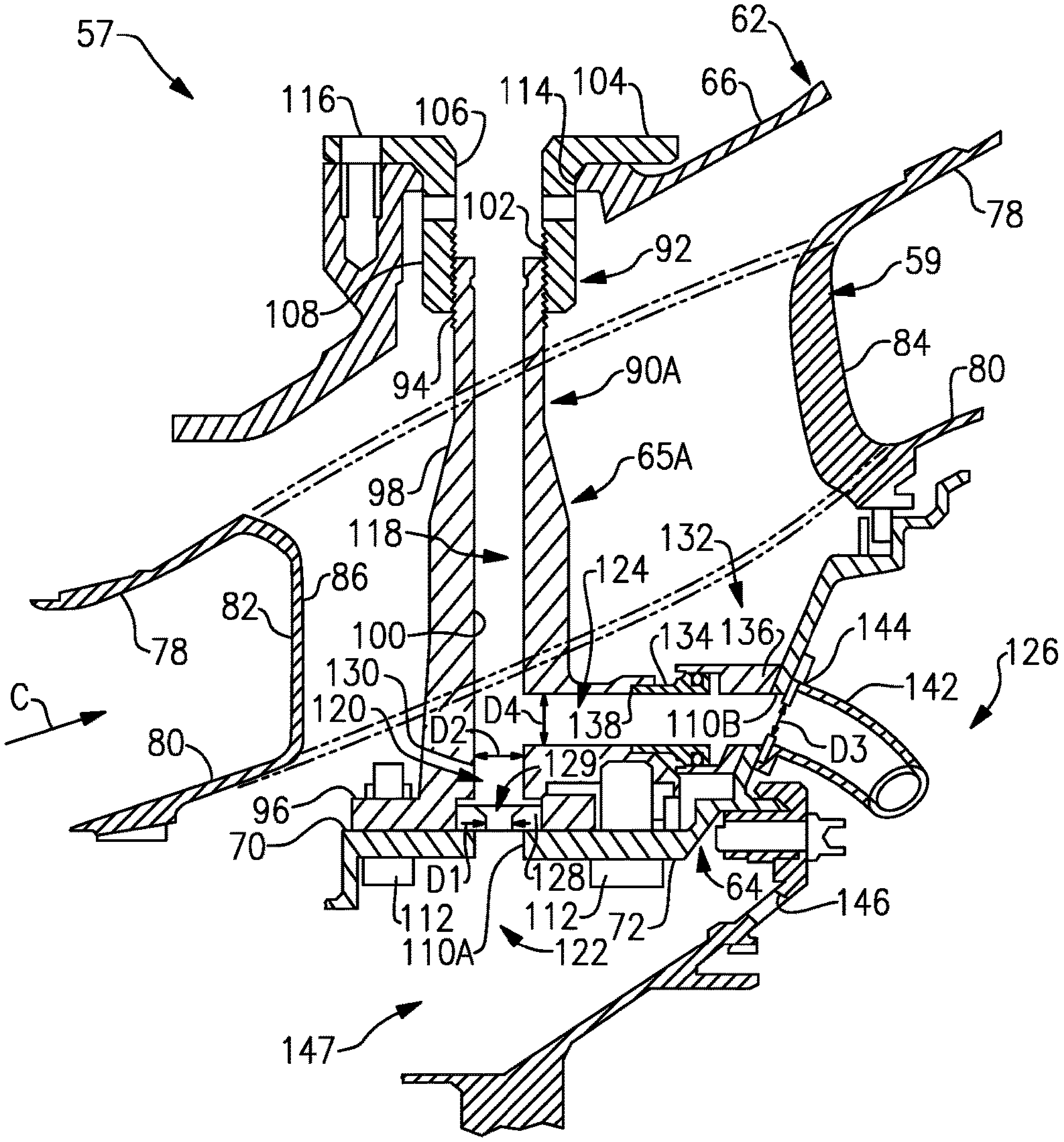
57
116
106
114
104
66
62
78
102
92
59
108
94
90A
84
80
98
65A
118
132
124
86
82
78
100
134
136
144
126
130
142
C
120
D2
D4
138
110B
D3
80
129
96
70
D1
128
64
146
112
112
72
110A
122
147

FIG.3

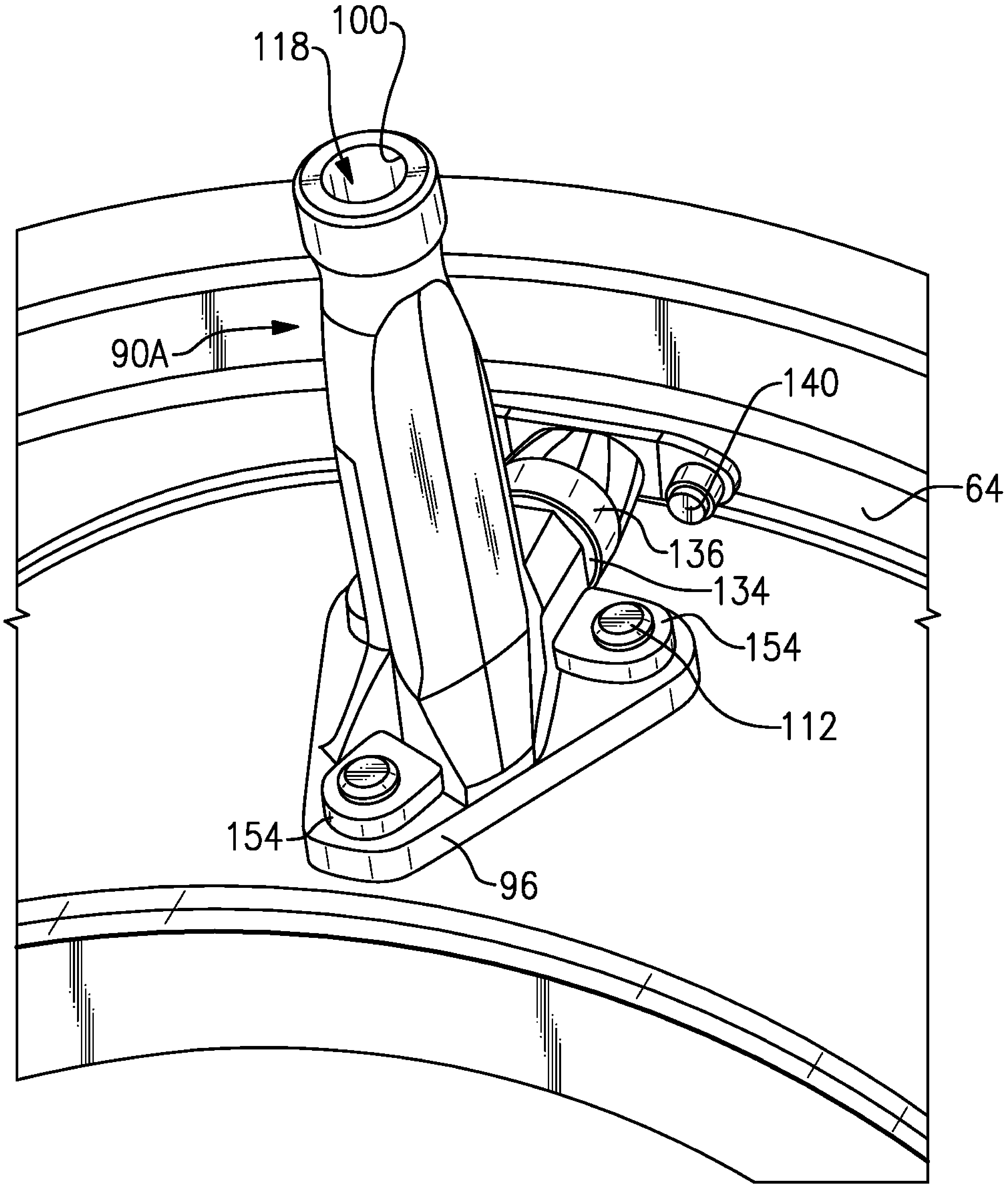

FIG.4

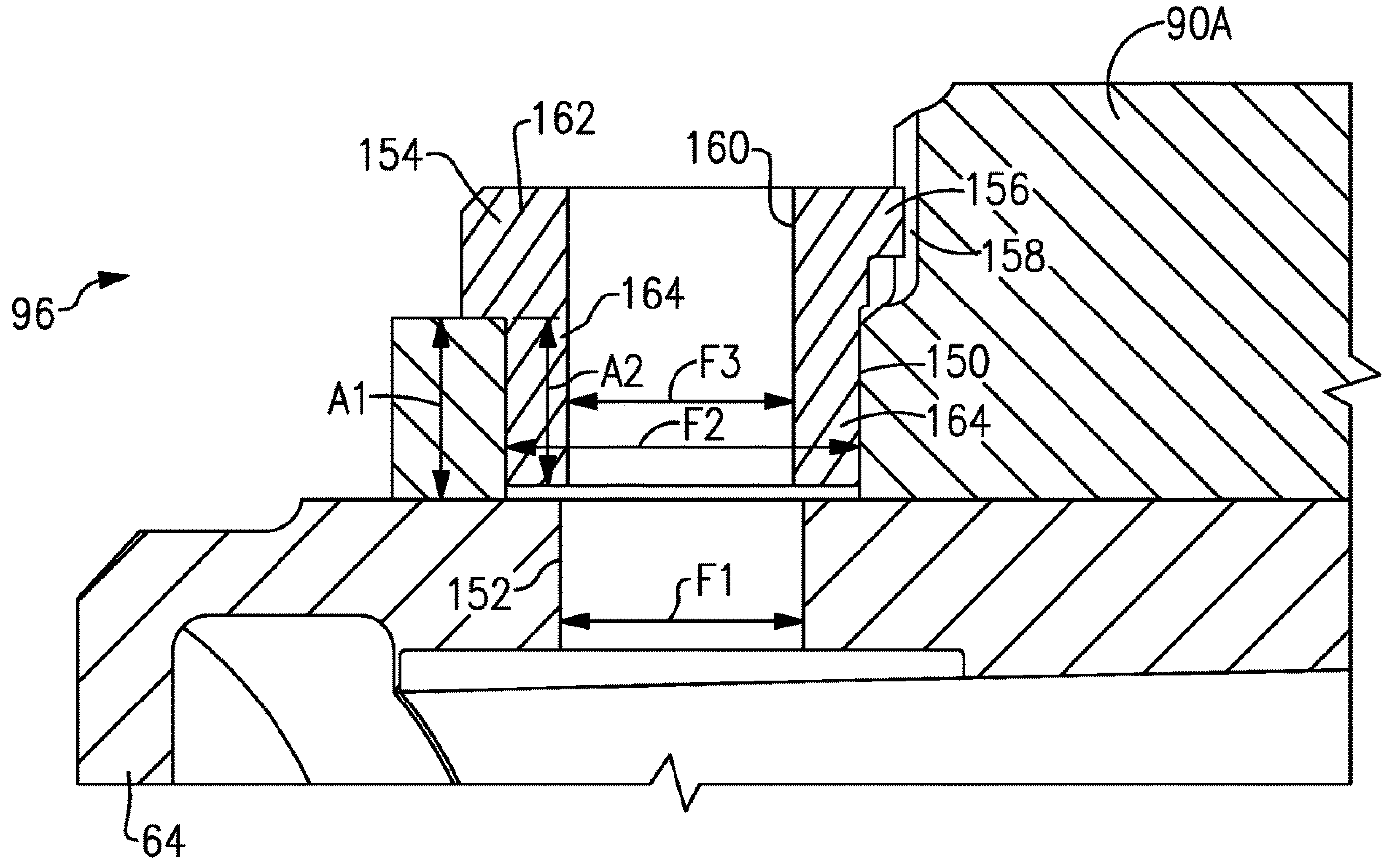
90A
162
154
160
156
158
96
164
150
A1
A2
F3
F2
164
152
F1
64

FIG.5

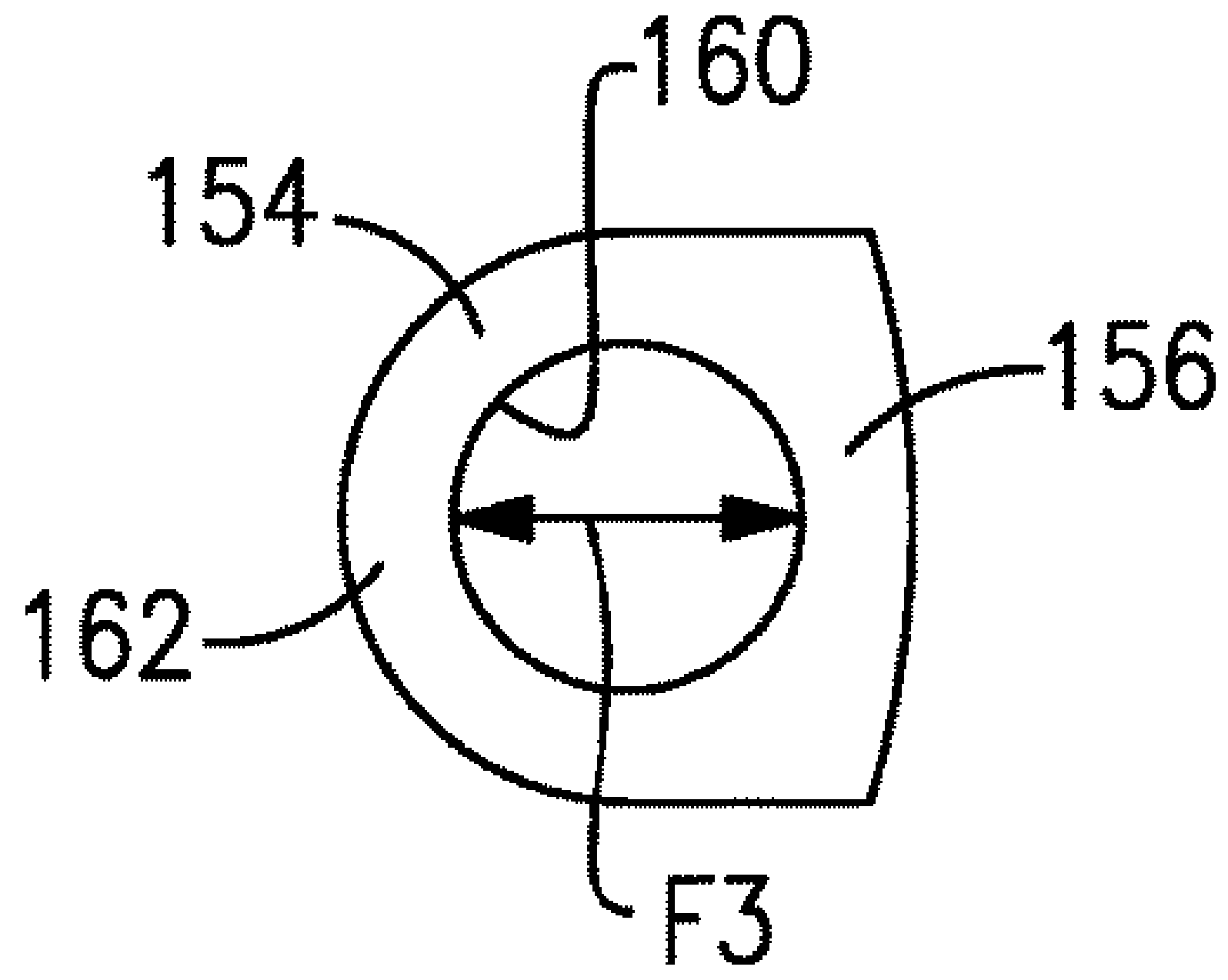
160
154
156
162
F3

FIG.6

# MID-TURBINE FRAME ASSEMBLY

## BACKGROUND

The present disclosure relates generally to a gas turbine engine, and in particular to a mid-turbine frame (MTF) included in a gas turbine engine.

A gas turbine engine typically includes a fan section, a compressor section, a combustor section, and a turbine section. Air entering the compressor section is compressed and delivered into the combustion section where it is mixed with fuel and ignited to generate a high-speed exhaust gas flow. The high-speed exhaust gas flow expands through the turbine section to drive the compressor and the fan section.

A mid-turbine frame (MTF) is positioned between a high pressure turbine stage and a low pressure turbine stage of a gas turbine engine. The MTF supports one or more bearings and transfers bearing loads from an inner portion of the gas turbine engine to an outer engine frame. The MTF also serves to route air from the high pressure turbine stage to the low pressure turbine stage.

## SUMMARY

In one exemplary embodiment, a fastener assembly includes a first component that includes a bushing opening. A second component includes a fastener opening. A threaded bushing is at least partially located within the bushing opening. A fastener extends through the fastener opening and engages the bushing.

In a further embodiment of the above, the first component is an inner frame case and the second component is a tie rod.

In a further embodiment of any of the above, the tie rod is made of a first material and the bushing is made of a second dissimilar material.

In a further embodiment of any of the above, the bushing includes a flange and a cylindrical portion.

In a further embodiment of any of the above, the flange includes a tab for engaging a portion of the tie rod to prevent the bushing from rotating.

In a further embodiment of any of the above, the tab includes an edge having a radius.

In a further embodiment of any of the above, the cylindrical portion extends within the bushing opening.

In a further embodiment of any of the above, the bushing opening includes a first axial length and the cylindrical portion includes a second axial length. The first axial length is greater than the second axial length.

In a further embodiment of any of the above, the second axial length is between 80% and 95% of the first axial length.

In another exemplary embodiment, a gas turbine engine includes a mid-turbine frame located axially between a first turbine and a second turbine. The mid-turbine frame includes an inner frame case which includes a bushing opening. A tie rod includes a fastener opening. A threaded bushing is at least partially located within the bushing opening. A fastener extends through the fastener opening and engages the bushing.

In a further embodiment of any of the above, the bushing includes a flange and a cylindrical portion.

In a further embodiment of any of the above, the flange includes a tab for engaging a portion of the tie rod to prevent the bushing from rotating.

In a further embodiment of any of the above, the tab includes an edge having a radius.

In a further embodiment of any of the above, the cylindrical portion extends within the bushing opening.

In a further embodiment of any of the above, the bushing opening includes a first axial length and the cylindrical portion includes a second axial length. The first axial length is greater than the second axial length.

In a further embodiment of any of the above, the second axial length is between 80% and 95% of the first axial length.

In another exemplary embodiment, a method of cooling a portion of a gas turbine engine includes securing a tie rod relative to an inner frame case with a fastener. The fastener is contacted with a bushing located in at least one of the tie rod and inner frame case. Heat is transferred from the fastener through the bushing to prevent the fastener from creeping.

In a further embodiment of any of the above, the tie rod is made of a first material and the bushing is made of a second dissimilar material.

In a further embodiment of any of the above, the tie rod is made of a first material and the bushing is made of a second dissimilar material.

In a further embodiment of any of the above, the inner frame case includes a bushing opening for accepting the bushing and the tie rod includes a fastener opening for accepting the fastener.

In a further embodiment of any of the above, the bushing opening includes a first axial length and the bushing includes a cylindrical portion having a second axial length. The first axial length is greater than the second axial length.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of an example gas turbine engine.

FIG. **2** is a schematic perspective view of an example mid-turbine frame in the gas turbine engine.

FIG. **3** is a section view taken along line **3**-**3** of FIG. **2**.

FIG. **4** is a perspective view of an example tie rod.

FIG. **5** is a section view of an example bushing.

FIG. **6** is a top view of the example bushing.

## DETAILED DESCRIPTION

FIG. **1** schematically illustrates a gas turbine engine **20**. The gas turbine engine **20** is disclosed herein as a two-spool turbofan that generally incorporates a fan section **22**, a compressor section **24**, a combustor section **26** and a turbine section **28**. Alternative engines might include an augmentor section (not shown) among other systems or features. The fan section **22** drives air along a bypass flow path B in a bypass duct defined within a nacelle **15**, while the compressor section **24** drives air along a core flow path C for compression and communication into the combustor section **26** then expansion through the turbine section **28**. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

The exemplary engine **20** generally includes a low speed spool **30** and a high speed spool **32** mounted for rotation about an engine central longitudinal axis A relative to an engine static structure **36** via several bearing systems **38**. It should be understood that various bearing systems **38** at various locations may alternatively or additionally be provided, and the location of bearing systems **38** may be varied as appropriate to the application.

The low speed spool **30** generally includes an inner shaft **40** that interconnects a fan **42**, a first (or low) pressure compressor **44** and a first (or low) pressure turbine **46**. The inner shaft **40** is connected to the fan **42** through a speed change mechanism, which in exemplary gas turbine engine **20** is illustrated as a geared architecture **48** to drive the fan **42** at a lower speed than the low speed spool **30**. The high speed spool **32** includes an outer shaft **50** that interconnects a second (or high) pressure compressor **52** and a second (or high) pressure turbine **54**. A combustor **56** is arranged in exemplary gas turbine **20** between the high pressure compressor **52** and the high pressure turbine **54**. A mid-turbine frame **57** of the engine static structure **36** is arranged generally between the high pressure turbine **54** and the low pressure turbine **46**. The mid-turbine frame **57** further supports bearing systems **38** in the turbine section **28**. The inner shaft **40** and the outer shaft **50** are concentric and rotate via bearing systems **38** about the engine central longitudinal axis A which is collinear with their longitudinal axes.

The core airflow is compressed by the low pressure compressor **44** then the high pressure compressor **52**, mixed and burned with fuel in the combustor **56**, then expanded over the high pressure turbine **54** and low pressure turbine **46**. The mid-turbine frame **57** includes airfoils **59** which are in the core airflow path C. The turbines **46**, **54** rotationally drive the respective low speed spool **30** and high speed spool **32** in response to the expansion. It will be appreciated that each of the positions of the fan section **22**, compressor section **24**, combustor section **26**, turbine section **28**, and fan drive gear system **48** may be varied. For example, gear system **48** may be located aft of combustor section **26** or even aft of turbine section **28**, and fan section **22** may be positioned forward or aft of the location of gear system **48**.

The engine **20** in one example is a high-bypass geared aircraft engine. In a further example, the engine **20** bypass ratio is greater than about six (6), with an example embodiment being greater than about ten (10), the geared architecture **48** is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine **46** has a pressure ratio that is greater than about five. In one disclosed embodiment, the engine **20** bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor **44**, and the low pressure turbine **46** has a pressure ratio that is greater than about five 5:1. Low pressure turbine **46** pressure ratio is pressure measured prior to inlet of low pressure turbine **46** as related to the pressure at the outlet of the low pressure turbine **46** prior to an exhaust nozzle. The geared architecture **48** may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section **22** of the engine **20** is designed for a particular flight condition—typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft (10,668 meters), with the engine at its best fuel consumption—also known as "bucket cruise Thrust Specific Fuel Consumption ('TSFC')"—is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. "Low fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. "Low corrected fan tip speed" is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of $[(\text{Tram } ^\circ \text{ R})/(518.7^\circ \text{ R})]^{0.5}$. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150 ft/second (350.5 meters/second).

The example gas turbine engine includes fan **42** that comprises in one non-limiting embodiment less than about 26 fan blades. In another non-limiting embodiment, the fan section **22** includes less than about 20 fan blades. Moreover, in one disclosed embodiment low pressure turbine **46** includes no more than about 6 turbine rotors schematically indicated at **34**. In another non-limiting example embodiment low pressure turbine **46** includes about 3 turbine rotors. A ratio between number of fan blades **42** and the number of low pressure turbine rotors is between about 3.3 and about 8.6. The example low pressure turbine **46** provides the driving power to rotate the fan section **22** and therefore the relationship between the number of turbine rotors **34** in low pressure turbine **46** and number of blades **42** in the fan section **22** disclose an example gas turbine engine **20** with increased power transfer efficiency.

FIG. **2** is a schematic perspective view of one embodiment of the mid-turbine frame **57**. The schematic view shown in FIG. **2** is high level conceptual view and is intended to illustrate relative positioning of various components, but not actual shape of various components. The mid-turbine frame **57** includes an outer frame case **62**, an inner frame case **64**, and a plurality of hollow spokes **65**. The outer frame case **62** includes an outer diameter surface **66**. The inner frame case **64** includes an outer diameter surface **70** and an inner diameter surface **72**. In the embodiment shown in FIG. **2**, six hollow spokes **65** are distributed around the circumference of the inner frame case **64** to provide structural support between the inner frame case **64** and the outer frame case **62**. In alternative embodiments, the mid-turbine frame **57** can have more or less than six hollow spokes.

The inner frame case **64** supports the rotor assembly via the bearing systems **38** (shown in FIG. **1**), and distributes the force from the inner frame case **64** to the outer frame case **62** via the plurality of hollow spokes **65**. Attachment of the hollow spokes **65** to the outer frame case **62** is provided at a plurality of bosses **75** located circumferentially around the outer diameter surface **66** of the outer frame case **62**.

In one embodiment, attachment of the hollow spokes **65** at the plurality of bosses **75** may be secured by a retaining nut **92** (shown in FIG. **3**) that allows the hollow spokes **65** to be tensioned. The hollow spokes **65** can be tensioned via a threaded connection so as to remain in tension during substantially all operating conditions of gas turbine engine **20**. Apertures **76** formed in each of the plurality of bosses **75** allow cooling airflow to be distributed into a hollow portion of each of the hollow spokes **65**. In this way, the cooling airflow is directed from the outer diameter through the hollow portions of the cooled hollow spokes **65** towards the inner frame case **64**. The cooling airflow can function to cool the hollow spokes **65** and also to cool components radially inward of the inner frame case **64**, such as the bearing systems **38**. The cooling airflow is then directed to the low-rotor cavity **126** to cool the turbine rotors.

FIG. **3** is a cross-sectional view of the mid-turbine frame **57** taken along line **3**-**3** of FIG. **2**. A hollow spoke **65**A is one example of the hollow spokes **65** shown in FIG. **2**. The hollow spoke **65**A extends from the outer frame case **62** through the airfoil **59** to the inner frame case **64**. The airfoil **59** extends from an outer platform **78** to an inner platform **80**. In the illustrated embodiment, the airfoil **59**, the outer platform **78**, and the inner platform **80** are integrally formed, and are all positioned radially inward of the outer frame case **62** and radially outward of the inner frame case **64**. The airfoil **59**, the outer platform **78**, and the inner platform **80** define a portion of the core flow path C at the mid-turbine frame **57**. The airfoil **59** extends axially from a leading edge **82** to a trailing edge **84**. The airfoil **59** is oblong so as to be longer in the axial direction than in the circumferential direction. The airfoil **59** has a hollow interior **86**, which is also relatively narrow in a chordal direction.

In the illustrated embodiment, the hollow spoke **65**A includes a tie rod **90**A and the retaining nut **92**. The tie rod **90**A is an elongated hollow tube that includes a threaded surface **94** at a radially outer end and a flange **96** at a radially inner end. The threaded surface **94** is on an outer surface **98** of the tie rod **90**A. An inner passage surface **100** of the tie rod **90**A defines an inlet passage **118** through the tie rod **90**A. The tie rod **90**A tapers along its length from the flange **96** at its radially inner end to the threaded surface **94** at its radially outer end.

The retaining nut **92** includes a threaded surface **102** at a radially inner end of the retaining nut **92** and a flange **104** at a radially outer end of the retaining nut **92**. The threaded surface **102** is on an inner surface **106** of the retaining nut **92**. The flange **104** extends outward from an outer surface **108** of the retaining nut **92**.

In the illustrated embodiment, the flange **96** of the tie rod **90**A abuts against the inner frame case **64** so that the inner passage surface **100** aligns with a hole **110**A in the inner frame case **64**. The flange **96** is attached to the inner frame case **64** via threaded fasteners **112**, such as bolts. The retaining nut **92** extends through a hole **114** in the outer frame case **62** such that the flange **104** abuts against the outer diameter surface **66** of the outer frame case **62**. The flange **104** is attached to the outer frame case **62** via a bolt **116**. The bolt **116** extends through the flange **104** into the outer frame case **62**. The tie rod **90**A is threaded into the retaining nut **92** to attach the tie rod **90**A to the retaining nut **92**. In the illustrated embodiment, a portion but not all of the threaded surface **94** overlaps with a portion but not all of the threaded surface **102**.

During assembly, the tie rod **90**A is inserted through the hollow interior **86** of the airfoil **59** in a direction from radially inward to radially outward. The inner frame case **64** is then positioned radially inward of the tie rod **90**A and attached to the tie rod **90**A by the threaded fasteners **112**. The retaining nut **92** is then inserted through the hole **114** and threadedly engaged with the tie rod **90**A. The retaining nut **92** can be tightened, as desired, in a manner described below. Once the retaining nut **92** is suitably tightened on the tie rod **90**A, the bolt **116** is inserted to fix the retaining nut **92** to the outer frame case **62** to prevent the retaining nut **92** from rotating and loosening.

Because the threaded surface **94** overlaps with the threaded surface **102** only partially, the threaded connection between the retaining nut **92** and the tie rod **90**A is variable. The retaining nut **92** does not bottom out at any particular point when threaded on the tie rod **90**A. This allows the retaining nut **92** to be threaded on the tie rod **90**A to an extent determined during assembly, not predetermined prior to assembly. This allows the hollow spoke **65**A, and the mid-turbine frame **57** in general, to be relatively insensitive to manufacturing tolerances.

The inlet passage **118** branches off between a first branch **120** extending into a bearing support cavity **122** and a second branch **124** extending into a low-rotor cavity **126**. The first branch **120** extends in a radially inward direction through the inner frame case **64**.

A plug **128** is aligned with the first branch **120** and is located in an opening **130** in the hollow spoke **65**A adjacent the outer diameter surface **70** of the inner frame case **64**. The plug **128** includes an opening **129** having a conical radially outer portion that tapers to a cylindrical channel on a radially inner side. The cylindrical channel of the plug **128** includes a diameter D**1** that is smaller than a diameter D**2** defined by the inner passage surface **100**. In the illustrated example, the plug **128** includes a diameter D**1**, however, the diameter D**1** could be any dimension that is smaller than the dimension D**2** in order to control the amount of cooling airflow that travels into the bearing support cavity **122**. Although the plug **128** is shown contacting the hollow spoke **65***a* and the inner frame case **64**, the plug **128** could be located anywhere within the first branch **120**.

In another example embodiment, the plug **128** could be solid and prevent the cooling airflow from entering the bearing support cavity **122** so the entire cooling airflow must travel through the second branch **124**. In yet another example embodiment, the opening **130** in the tie rod **90**A could be reduced to the diameter D**1** so that the plug **128** could be eliminated.

The second branch **124** extends in an axially downstream direction perpendicular to the first branch **120**. Although the second branch **124** is shown being perpendicular to the first branch **120**, the second branch **124** could be within 30 degrees of being perpendicular to the first branch **120**. The second branch **124** is in fluid communication with the low rotor cavity through to a fitting **132** that extends through the inner frame case **64** and connects to a swirler tube **142**.

The fitting **132** includes a transfer tube **134** pressed, welded, or brazed into an opening **138** in the hollow spoke **65**A on a first end and engages a cup boss **136** on a second end. A piston ring creates a seal between an outer diameter of the transfer tube **134** and the cup boss **136**. As shown in FIGS. **4** and **5**, the cup boss **136** is fastened to the inner frame case **64** with fasteners **140** and is aligned with a hole **110**B in the inner frame case **64**. The fasteners **140** also secure the swirler tube **142** to an opposite side of the inner frame case **64** from the cup boss **136**. The swirler tube **142** directs the cooling airflow into the low rotor cavity in the direction of rotation of the low rotor to reduce turning and aerodynamic losses in the cooling airflow. By pre-swirling the cooling air flow prior to entering the low-rotor cavity **126**, the heat up of the cooling air flow is reduced which lowers a temperature of the low-rotor cavity.

A restricting ring **144** is located between the swirler tube **142** and the inner diameter surface **72**. The restricting ring **144** includes a diameter D**3** which is smaller than a diameter D**4** of the second branch **124**. The restricting ring **144** restricts the amount of cooling airflow through the second branch **124** to aid in dividing the amount of cooling airflow traveling into the bearing support cavity **122** and the low-rotor cavity **126**. Although the restricting ring **144** is shown between the swirler tube **142** and the inner frame case **64**, the restricting ring **144** could be located anywhere within the second branch **124** to reduce the cooling airflow into the low-rotor cavity **126**. Alternatively, or in addition to the restricting ring **144**, a portion of the second branch **124** may include a portion with a reduced diameter, such as reducing a diameter of the second branch **124** extending through the transfer tube **134**, the cup boss **136**, or the hole **110**B to meter the cooling airflow.

In one example, the a first portion of cooling airflow travels into the bearing support cavity **122** and a second portion of cooling airflow travels into the low-rotor cavity **126**, with the second portion being greater than the first portion.

A connectivity hole **146** is located in the inner frame case **64**. The connectivity hole **146** fluidly connects a mid-turbine frame cavity **147** and the low-rotor cavity to supply cooling airflow from the mid-turbine frame cavity **147** without having the cooling airflow mix in the bearing support cavity **122**.

As shown in FIGS. **4** and **5**, the tie rod **90**A includes bushing openings **150** in the flange **96** that align with a corresponding fastener opening **152** in the inner frame case **64**. In the illustrated example, there are three bushing openings **150** in the flange **96** and three corresponding fastener openings **152** in the inner frame case **64**. Alternatively, there may be four fastener openings **152** and four bushing openings **150**.

Bushings **154** are placed within the bushing openings **150** in the tie rod **90**A. The bushings **154** include a flange **162** and a cylindrical portion **164** extending from the flange **162**. A threaded bushing fastener opening **160** extends through the flange **162** and the cylindrical portion **164** of the bushing **154** and aligns with the fastener opening **152** in the inner frame case **64**. The threaded openings **160** and the fastener openings **152** accept the threaded fasteners **112**. The bushing **154** is made of a dissimilar material from the tie rod **90**A. The bushing **154** includes a tab **156** having an edge with a radius that extends from the flange **162** and prevents rotation of the bushing **154** relative to the tie rod **90**A during installation or disassembly by engaging a portion **158** of the tie rod **90**A. The radius on the tab **156** is larger than a radius of an edge of the flange **162** opposite the tab **156**. In another example, the tab **156** does not include a radius.

To ensure that the tie rod **90**A fits flush against the inner frame case **64**, an axial length A1 of the bushing opening **150** is larger than an axial length A2 of the cylindrical portion **164** on the bushing **154**. In the illustrated example, the axial length A2 of the cylindrical portion **164** of the bushing **154** extends approximately 80% to 95% of the axial length A1 of the bushing opening **150**. Because the bushing **154** contacts a significant portion of the threaded fastener **112**, heat that accumulates in the threaded fastener **112** can be dissipated through the bushing **154** to prevent the threaded fastener **112** from creeping and reducing the roundness and stiffness of the mid-turbine frame **57**. The threaded fastener **112** may protrude from the bushing **154** or alternatively may be recessed within the bushing **154** to reduce the amount of radiant heat that may reach the threaded fastener **112**.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. The scope of legal protection given to this disclosure can only be determined by studying the following claims.

What is claimed is:

**1**. A fastener assembly comprising:

a tie rod including a tie rod flange and a bushing opening located in the tie rod flange;

an inner frame case including a fastener opening;

a threaded bushing at least partially located within the bushing opening, wherein the threaded bushing includes a cylindrical portion extending from a bushing flange and the cylindrical portion is located within the bushing opening and the bushing flange is spaced from the bushing opening; and

a fastener extending through the fastener opening and engaging the bushing, wherein the bushing opening includes a first axial length extending between a radially inner edge and a radially outer edge of the tie rod flange and the cylindrical portion of the threaded bushing includes a second axial length extending from the bushing flange to a distal end surface of the cylindrical portion, with the first axial length greater than the second axial length, wherein the bushing flange includes a tab for engaging a portion of the tie rod to prevent the bushing from rotating and the tab includes an edge having a radius that is larger than a radius of an edge of the bushing flange opposite the tab.

**2**. The assembly of claim **1**, wherein the tie rod is made of a first material and the bushing is made of a second dissimilar material.

**3**. The assembly of claim **1**, wherein the second axial length is between 80% and 95% of the first axial length.

**4**. The assembly of claim **1**, wherein the distal end surface of the cylindrical portion on the threaded bushing is spaced from the inner frame case by a clearance gap.

**5**. The assembly of claim **1**, wherein the tie rod includes a projecting portion extending from the tie rod flange and the tab engages the projecting portion of the tie rod to prevent the bushing from rotating.

**6**. A gas turbine engine comprising:

a mid-turbine frame located axially between a first turbine and a second turbine, the mid-turbine frame comprising:

- an inner frame case including a fastener opening;
- a tie rod including a tie rod flange having a bushing opening and a projecting portion extending from the tie rod flange;
- a threaded bushing at least partially located within the bushing opening, wherein the threaded bushing includes a cylindrical portion extending from a bushing flange and the cylindrical portion is located within the bushing opening and the bushing flange is spaced from the bushing opening, wherein the bushing flange includes a tab for engaging the projecting portion of the tie rod to prevent the bushing from rotating, wherein the tab includes an edge having a radius that is larger than a radius of an edge of the bushing flange opposite the tab; and
- a fastener extending through the fastener opening and engaging the bushing.

**7**. The gas turbine engine of claim **6**, wherein the bushing opening includes a first axial length and the cylindrical portion includes a second axial length from the bushing flange to a distal end surface of the cylindrical portion, with the first axial length greater than the second axial length.

**8**. The gas turbine engine of claim **7**, wherein the second axial length is between 80% and 95% of the first axial length and the tie rod is made of a first material and the bushing is made of a second dissimilar material.

**9**. The gas turbine engine of claim **6**, wherein the cylindrical portion includes a distal end spaced from the inner frame case by a clearance gap.

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